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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 081

WATERBORNE UNDERWATER HULL CLEANING OF NAVY SHIPS

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SECTION 1.
GENERAL INFORMATION

081–1.1 BACKGROUND

081–1.1.1 GENERAL. Biological fouling of the underwater hull and appurtenances of surface ships and submarines can be removed mechanically between regularly scheduled drydockings to restore effectiveness of intact antifouling paint systems. This chapter provides guidance on criteria for evaluating fouling severity, antifouling/anticorrosive (AF/AC) paint condition, intervals of cleaning, and methods to be used. Submarine requirements, where unique, are indicated.

081–1.1.1.1 Total ship performance and Fleet capability can be enhanced by waterborne cleaning and maintenance (in place of drydocking for cleaning). This practice increases ship availability and minimizes associated costs. Removal of fouling while the ship is waterborne can restore most, if not all, of the post-drydocking performance and economy of operation. Regular hull cleaning prevents calcareous fouling from progressing to a point where fouling damages underlying anticorrosive paint coatings. The specific advantages are described in the following paragraphs.

081–1.1.2 ENERGY SAVINGS. Commercial and Naval experience has demonstrated that appreciable savings in energy are obtainable by preserving smooth underwater hull and propeller surfaces. Fuel savings of more than 15 percent have been realized as a result of hull cleaning and propeller polishing of fossil–fueled ships. Trials conducted before and after cleaning nuclear–powered ships have demonstrated significant speed increases, or reductions in power necessary to attain a given speed. Progressive biological fouling causes increased energy consumption resulting from increased hull drag, diminished propeller performance, and clogged sea chests and associated piping.

081–1.1.3 ENHANCED SONAR EFFICIENCY. Fouling of the sonar dome diminishes sonar efficiency; cleaning of the surface ship and submarine sonar domes restores the effectiveness of the sonar system.

081–1.1.4 REDUCED SHIP SELF–NOISE. Removal of fouling reduces ship self–noise, thus increasing the ships antisubmarine warfare effectiveness.

081–1.1.5 EXTENDED PAINT SERVICE LIFE. The service life of a properly applied non–ablative vinyl antifouling paint system, normally 2 years, can be extended to as much as 7 or more years when supported over its lifetime by regularly scheduled inspections and periodic cleanings as part of the hull cleaning program. The service life of a properly applied ablative antifouling paint system, normally 5 to 7 years, can be maintained and extended when supported over its lifetime by regularly scheduled inspections and periodic cleanings as part of the hull cleaning program.

081–1.1.6 CORROSION CONTROL. Calcareous fouling accelerates paint system failure, thereby increasing the hull structure’s susceptibility to corrosion.

081–1.2 PROGRESSIVE FOULING PATTERNS

081–1.2.1 GENERAL. The biological fouling of Navy ships is a recurring process following identifiable patterns of growth. Relatively few types of organisms are responsible for hull fouling and they tend to develop in the order listed in paragraphs 081–1.2.2 through 081–1.2.5 (depending on geographical locality).

081–1.2.2 SLIME. Formation of slime is the first step in the fouling process. Almost any object immersed in seawater rapidly accumulates a coating of slime, consisting of bacteria, fungi, protozoa, and algae. Bacteria frequently are attached within one–half hour of wetting the surface, and slime can often be felt by hand within an hour. The coating of slime is smooth and generally follows hull contours.

081–1.2.3 GRASS. Grass is a form of multicellular green and brown algae. It forms most heavily near the waterline, where adequate light is available for photosynthesis. It is less evident as depth increases, and the dominant color changes from green to brown.

081–1.2.4 HARD FOULING. The dominant organisms in this stage of fouling are barnacles (usually acorn) and tubeworms (serpulids). Acorn barnacles have conical hard shells with jagged tops. Tubeworms form intertwined tubes lying along or projecting out from the hull.

081–1.2.5 COMPOSITE. In advanced stages of fouling, the ship will be affected by slime, grass, barnacles, and tubeworms. In addition, this stage of fouling will include soft shell–less animal forms, such as hydroids, anemones, and tunicates (sea squirts).

NOTE

Most of the slimes, grass, and soft animal life forms are washed off an active Naval ship while underway. The calcareous forms, barnacles and tubeworms, remain as the primary fouling problems.

081–1.2.6 FOULING RATING (FR). The fouling rating scale (Table 081–1–1) describes the 10 most frequently encountered fouling patterns in order of increasing severity. Representative photographs of each fouling pattern are provided in Figure 081–1–1.

081–1.2.7 FOULING RATING (FR) SCALE. A rating number has been assigned to each of the 10 fouling patterns on a scale of 0 to 100 in 10–point increments. The lowest number represents a clean hull and the higher numbers represent fouling organism populations of increasing density and variety.

081–1.3 FOULING CRITICAL SURFACES

081–1.3.1 GENERAL. In addition to generalized hull fouling, a ship has a number of specific locations where fouling can be particularly harmful. Fouling on the propeller can account for as much as 50 percent of the increased energy demand associated with a light to moderately fouled hull. The critical locations and the types of fouling most likely to impair function are described in the following paragraphs.

081–1.3.2 PROPELLERS. The dominant form of fouling on propellers is hard fouling, such as barnacles and tubeworms. The presence of even immature barnacles or tubeworms causes a severe loss in propeller efficiency. Examples of such fouling are defined in Table 081–1–1 and illustrated in Figure 081–1–1. In addition, the presence of surface roughness can result in a loss in propeller efficiency. Propeller surface roughness is determined by use of a Ship Propeller Roughness Gauge (Rubert Comparator Scale).

081–1.3.3 SONAR DOMES. On sonar domes with a rubber antifouling coating, slime and grass (fouling ratings of FR–10 to FR–30) are the predominant fouling forms to be expected. Failure of that antifouling coating, however, will allow hard fouling (FR–50 and above) to form. Sonar performance deteriorates rapidly after fouling progresses beyond a fouling rating of FR–30.

081–1.3.4 DOCKING BLOCK BEARING SURFACES. The unpainted surfaces that rested on the docking blocks during the most recent drydocking are more susceptible to fouling than the rest of the underwater body. These surfaces often can be identified by the sharp delineation of fouling at their boundaries. Fouling ratings of FR–70 or above are common over these bearing surfaces. Particular attention to hull plating condition is critical in these areas because of their greater susceptibility to corrosion.

081–1.3.4.1 As time out of dry dock increases, the outline of the docking block bearing surfaces becomes less well defined because of the outward spread of fouling. The rate at which the fouling spreads outward also reflects the effectiveness of the antifouling paint.

Table 081–1–1. FOULING RATINGS (FR) IN ORDER OF INCREASING SEVERITY

Fouling Rating (FR)	Description
0	A clean, foul-free surface; red AF paint (for a ship just out of drydock)
10	Continuous graduations of shades of red and green (incipient slime)
20	Slime as dark green patches with yellow or brown colored areas (advanced slime)
30	Grass as filaments up to 3 inches (76 mm) in length, projections up to 1/4 inch (6.4 mm) in height; or a flat network of filaments, green, yellow, or brown in color
40	Calcareous fouling on edges, welded seams, corners, or as discrete patches covering flat areas roughly 9 to 10 inches (229 to 254 mm) in diameter
50	Random and scattered tubeworms or barnacles (or both) on slightly curved or flat surfaces
60	Area distribution of tubeworms or barnacles, 1/4 inch (6.4 mm) in diameter or less; fouling does not completely cover or blank out surface
70	Tubeworms and barnacles completely cover surface in patches exceeding 9 to 10 inches (229 to 254 mm) in diameter. Tubeworms lying flat with radiating fringes of growth or barnacles (1/4 mm) in diameter or less
80	Tubeworms closely packed together and growing upright away from surface. Barnacles growing one on top of another. Calcareous shells appear clean or white in color
90	Dense growth of tubeworms with barnacles 1/4 inch (6.4 mm) or greater. Calcareous shells brown in color or with slime or grass overlay
100	All forms of fouling present, particularly soft sedentary animals without calcareous covering (tunicates)

081–1.3.5 SEA CHESTS. A fouling rating of FR–40 is generally first observed over covers and around the perimeter of sea chest gratings. Fouling ratings of FR–50 and above are later observed around and over the gratings and on the inner surfaces of sea chests. Fouling on the interior surfaces of gratings and sea chests is inaccessible to rotary brushes used for hull cleaning, and must be cleaned by other means, for example, hand–held scrapers and water jets.

081–1.3.6 MASKER EMITTER BELTS. The dominant form of fouling on masker emitter belts is hard fouling, such as barnacles and tubeworms. These hard calcareous organisms block emitter holes and rapidly deteriorate emitter belt performance. Emitter holes also become blocked by calcium deposits or silt ingestion.

081–1.3.7 PROPULSION SHAFTS. Fiberglass (GRP) coated shafts are normally covered with antifouling paint. As time out of drydock increases, paint can wear off, thereby exposing the white fiberglass (GRP) coating. This coating then tends to foul at an accelerated rate when compared to the painted shaft coating surface. The presence of any hard fouling on the shaft can be detrimental to the efficient rotation of the shaft in the water.

081–1.4 PAINT DETERIORATION RATING (PDR) SCALE

081–1.4.1 The 10 photographs presented in Figure 081–1–2 and described in Table 081–1–2 have each been assigned a numerical rating of increasing severity on a scale from PDR–10 to PDR–100 in 10–point increments. The first three ratings (PDR–10 through PDR–30) represent AF painted surface appearances associated with normal physical wear due to underwater cleaning action or hydrodynamic effects. The rating of PDR–40 is significant in that it indicates blistering due to internal failure of the paint system. Such blisters are not the result of cleaning, but may not be noticed until after a cleaning operation. Failure at the AC/AF interface results in a softer blister (PDR–40) which is more likely to be broken by cleaning. Relatively hard blisters (PDR–50) which have survived cleaning indicate a probable failure at the AC/steel interface. Subsequent ratings of PDR–60 to PDR–100 indicate advancing deterioration of the entire AC/AF paint system. Whenever a rating of PDR–40 or higher is found over a substantial portion of the hull, consult paragraphs 081–2.1.8 and 081–2.1.8.1 before planning any future hull cleaning actions.

Table 081–1–2. PAINT DETERIORATION RATINGS (PDR) FOR ANTIFOULING/ANTICORROSIVE (AF/AC) PAINT SYSTEM

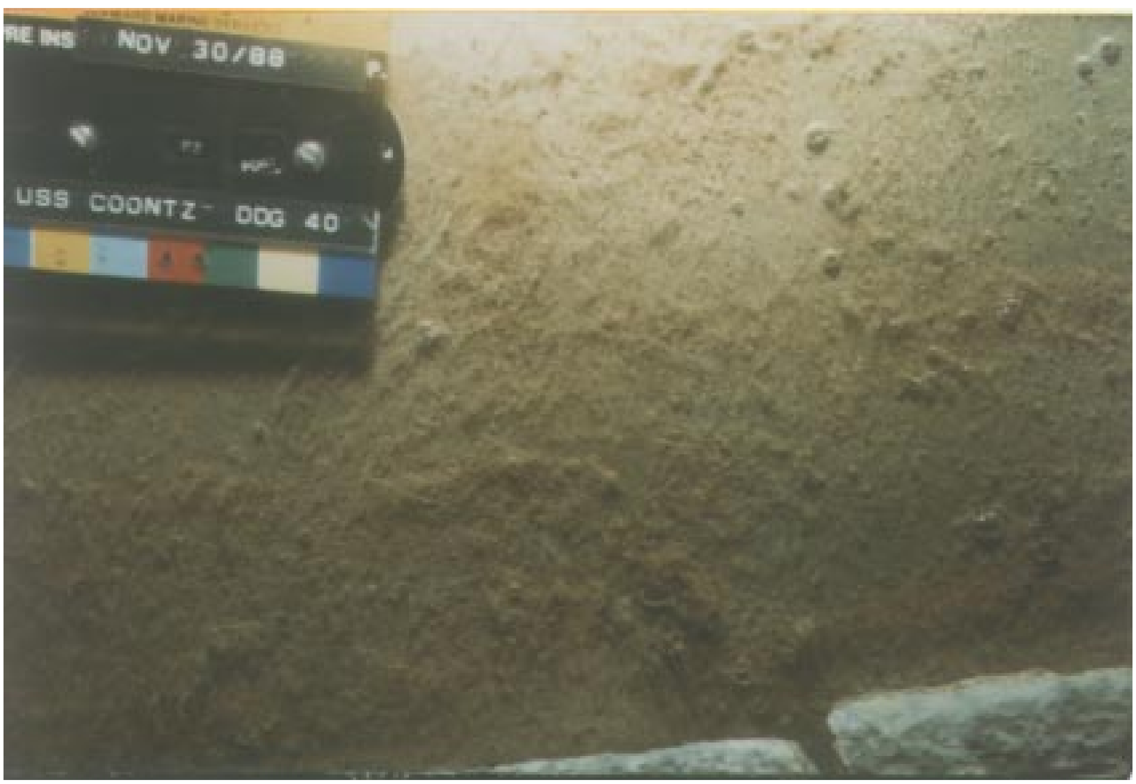
Paint Deterioration Rating (PDR)	Description
10	AF paint intact, red in color or with mottled pattern of light green and red
20	AF paint missing from edges, corners, seams, welds, rivet or bolt heads to expose AC paint
30	AF paint missing from slightly curved or flat areas to expose AC paint
40	AF paint missing from intact blisters to expose AC paint
50	AF blisters ruptured to expose intact AC paint
60	AF/AC paint missing or peeling to expose steel substrate, no corrosion present
70	AF/AC paint removed from edges, corners, seams, welds, rivet or bolt heads to expose steel substrate with corrosion present
80	Ruptured AF/AC blisters on slightly curved or flat surfaces with corrosion or corrosion stains present
90	Area corrosion of steel substrate with no AF/AC paint cover due to peeling or abrasion damage
100	Area corrosion showing visible surface evidence of pitting, scaling, and roughening of steel substrate

FR–0

FR–10

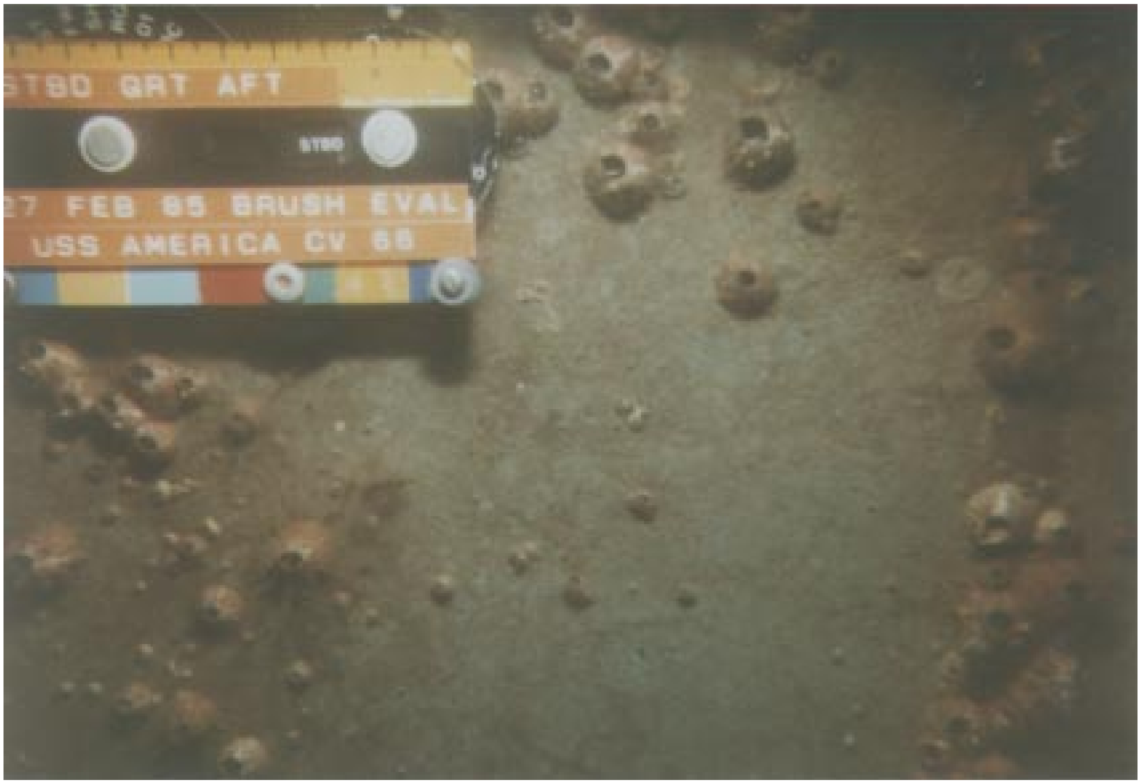
Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (Sheet 1 of 6).

FR–20



FR–30

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (Sheet 2 of 6).

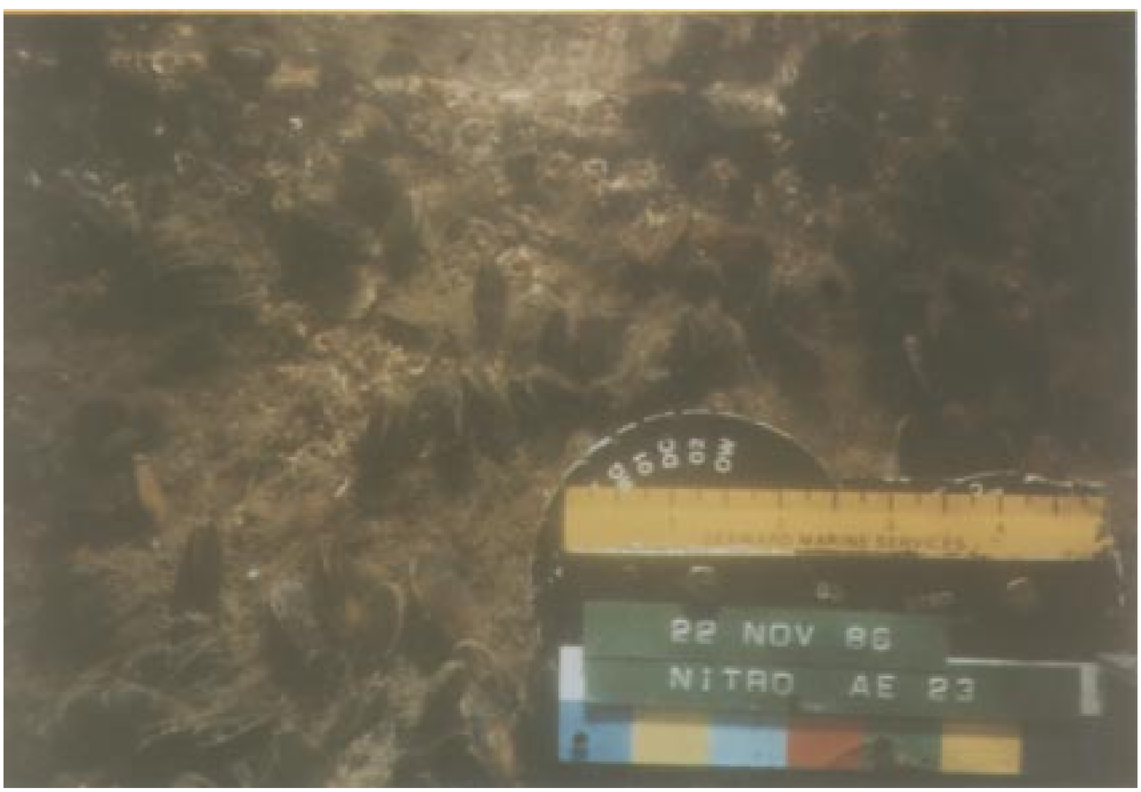


FR–40

FR–50

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (Sheet 3 of 6).

FR–80



FR–90

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (Sheet 5 of 6).

FR–100

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (Sheet 6 of 6).

PDR–10

PDR–20

Figure 081–1–2. Typical Paint Deterioration Ratings (PDR) for Paint of Increasing Deterioration (Sheet 1 of 5).

PDR–30

PDR–40

Figure 081–1–2. Typical Paint Deterioration Ratings (PDR) for Paint of Increasing Deterioration (Sheet 2 of 5).

PDR–50

PDR–60

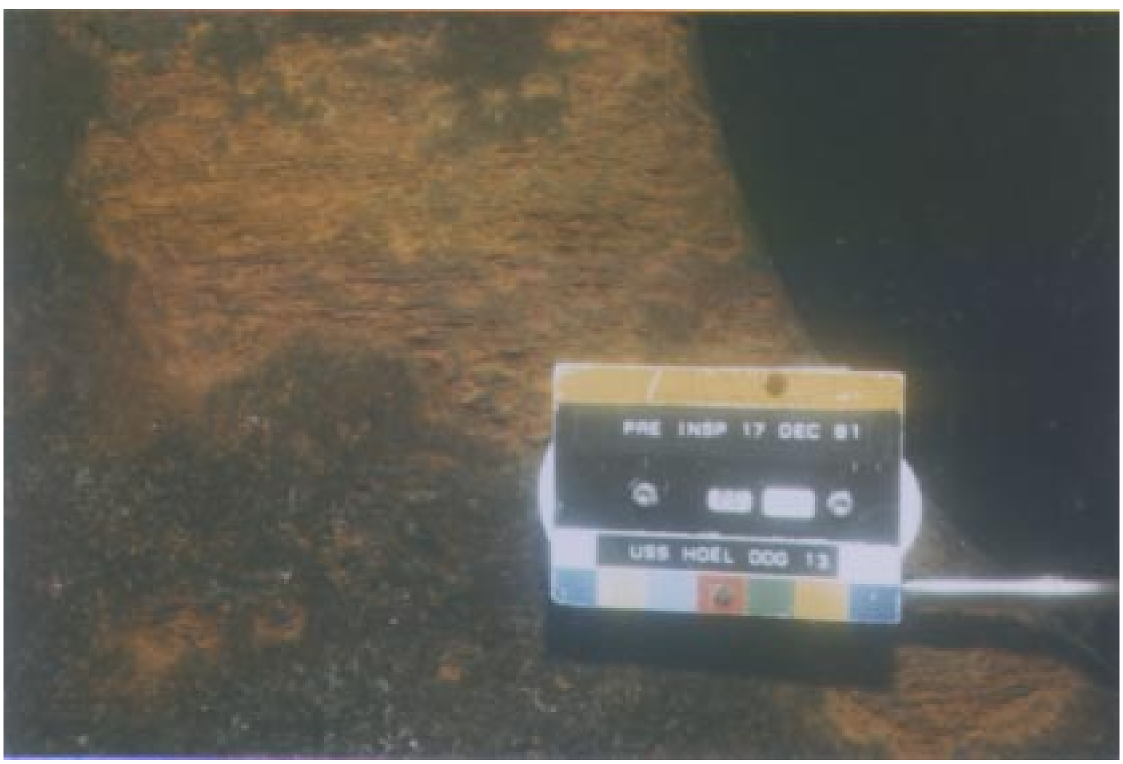
Figure 081–1–2. Typical Paint Deterioration Ratings (PDR) for Paint of Increasing Deterioration (Sheet 3 of 5).

PDR–70

PDR–80

Figure 081–1–2. Typical Paint Deterioration Ratings (PDR) for Paint of Increasing Deterioration (Sheet 4 of 5).

PDR–90



PDR–100

Figure 081–1–2. Typical Paint Deterioration Ratings (PDR) for Paint of Increasing Deterioration (Sheet 5 of 5).

SECTION 2.
CLEANING GUIDANCE

081–2.1 CLEANING INTERVAL CRITERIA AND SCHEDULING

081–2.1.1 GENERAL. Since the effects of fouling on speed and power may vary among ship classes, and since the rates of fouling growth will vary with the condition of the antifouling paint system, the quality and number of prior cleanings, and the ship's geographical area and operational profile, no specific cleaning intervals can be stated. It is therefore imperative that all ships be scheduled for precleaning inspection on regular intervals to determine if cleaning is necessary. Delaying full hull cleaning to the point where a significant amount of hard fouling has formed (fouling rating (FR) 50 and above for non–ablative anti–fouling paints; FR–40 for ablative and self–polishing paints) can result in damage to the paint system.

081–2.1.1.1 For hull cleaning and scheduling purposes, the following definitions apply:

FULL CLEANING: The term full cleaning refers to the cleaning of the entire underwater hull surface (that is, painted surfaces), propellers, and shafts.

INTERIM CLEANING: The term interim cleaning refers to the cleaning of propellers and shafts only. Interim cleanings are normally scheduled for all ships between regular full cleanings to take advantage of the significant fuel savings benefits of operating with clean, smooth running gear. Approximately 50 percent of the entire fuel savings benefit of cleaning an entire hull (that is, full cleaning) is attributable to the cleaning of propellers and shafts. All ships, irrespective of the hull coating formulation, will benefit from routine interim cleanings and inspections.

081–2.1.1.2 Differences in ship employment schedules and geographic operating areas may require variations in cleaning scheduling intervals, however, full hull cleaning shall not be accomplished on intervals of less than 6 months. Under normal circumstances, cleaning shall be conducted only when the fouling reaches the thresholds established in paragraph 081–2.1.1.3. Except in extenuating circumstances, cleaning properly prepared, newly painted hull surfaces should be unnecessary during the first 12 to 18 months after undocking. Ships which remain pierside in warm waters for extended periods of time after undocking will develop fouling more quickly and may require earlier cleaning. This 12– to 18–month window does not apply to unpainted surfaces such as propellers and masker emitter belts; therefore, ships should be scheduled for interim (propeller) cleanings on regular intervals immediately after undocking.

081–2.1.1.3 The decision to initiate a hull cleaning operation should be based on the results of precleaning hull inspections performed on regularly scheduled intervals. A secondary indication for the need to perform an underwater hull inspection is evidenced by ship performance indicators provided in paragraphs 081–2.1.6 and 081–2.1.6.1. The fact that these changes are due to fouling must be verified by underwater inspection of the ship's hull. Full hull cleaning shall be accomplished when a fouling rating of FR–50 or higher (over 10 percent of the hull) for non–ablative paints; FR–40 or higher for ablative and self–polishing paints, exclusive of docking block areas and appendages, is observed; interim cleaning when FR–30 or greater is observed on propeller surfaces. Rubber sonar domes shall be cleaned when FR–30 or greater is observed. Masker belts shall be cleaned when 15 percent blockage is observed on any belt section (that is, waterline to centerline). Propulsion shafts shall be cleaned when FR–40 or greater is observed (localized fouling concentrations should be spot–cleaned).

081–2.1.2 SCHEDULED DRYDOCKING. A ship's cleaning schedule should be adhered to until drydocking for new paint application. Deferral or cancellation of a ship's hull cleaning because of a scheduled upcoming drydocking often results in significant fuel penalties caused by dry–docking deferral. Underwater hull cleaning costs are quickly recouped by fuel savings, thereby justifying the decision to clean although a drydocking may be scheduled within 1 or 2 months. A ship's intended employment schedule must be reviewed prior to deferring cleaning for a near time scheduled drydocking for painting to determine if the fuel savings benefit recognized by cleaning can recoup the cost of cleaning. Should the drydocking schedule remain firm, once in dry dock a clean hull will reduce time and consequently dollars for the docking package.

081–2.1.3 PARTIAL VS. COMPLETE CLEANING. To ensure the greatest payoff for limited cleaning efforts, when time or other resources are limited, the priorities for underwater cleaning are:

a. Propellers

b. Forward one–third of the hull

c. After two–thirds of the hull.

081–2.1.3.1 Tests indicate that energy usage penalties caused by fouling occur in the foregoing order.

081–2.1.4 ABLATIVE AND SELF–POLISHING ANTIFOULING PAINTS. Ablative and self–polishing antifouling paints are softer than non–ablative vinyl antifouling paints and designed to wear away in small quantities while the ship is underway. Ships painted with these systems should still be regularly scheduled for interim cleaning and precleaning inspections. Precleaning inspections should be conducted over the entire hull to assess and document the paint system's performance. If, during a hull inspection or interim cleaning, fouling of FR–40 or greater, over 20 percent of the hull, exclusive of docking block areas and appendages, is observed on a hull coated with ablative or self–polishing paint, then a full hull cleaning should be accomplished. This decision to clean, when an FR–40 condition is noted, is critical regardless of the ship's employment schedule. Cleaning a fouled hull prior to an extended underway period will obviously improve performance and save fuel. Cleaning a fouled hull prior to an extended pier–side availability, especially in warm water, will slow fouling progression and extend the service life of the paint system even though it will not immediately save fuel.

081–2.1.5 FOULING RELEASE COTING SYSTEMS. Fouling release coating systems are designed with a low surface energy to reduce marine fouling's ability to permanently adhere to the coating when the ship is underway. The hydrodynamic forces cause the marine fouling to wash off the hull. Therefore hull cleaning is not permitted. However, ships coated with these systems should still be regularly scheduled for an interim cleaning and inspection. A precleaning inspection should be conducted over the entire hull to assess and document the coating system's performance. In the event that the ship is unable to reach the design speed of the coating or if the fouling was not removed during the last period in which ship speed exceeded the design speed, then hull cleaning may be required. If during a hull inspection or interim cleaning, fouling of FR–50 or greater is observed over 10 percent of a hull coated with a fouling release coating system, photographic documentation by Navy or Contractor divers should be obtained and forwarded immediately to NAVSEA Code 00C. NAVSEA will provide cleaning advice for ships coated with fouling release coating systems on a case basis. All requests should be submitted by fleet activities in the form of Naval messages utilizing the subject line: **WATERBORNE UNDERWATER HULL CLEANING.** Messages should include date of inspection, inspection activity, hull paint date and type, date of last underway period, maximum ship speed and duration within the last underway period, date of next scheduled drydocking, and inspection results. In no case should fouling release coating systems be cleaned without specific written approval by NAVSEA.

081–2.1.6 SHIP PERFORMANCE INDICATORS. Observed performance changes that lower a ship's ability to perform its mission or operate efficiently may be indications of the need for hull cleaning. When such deterioration occurs, conduct an underwater hull inspection to verify that fouling is the probable cause. Typical performance changes which may indicate a need for cleaning include the following:

a. A reduction of one knot in speed with shaft revolutions per minute (r/min) set for standard speed

b. An increase in excess of 5 percent in fuel required to maintain a specified shaft r/min (such as for standard speed), with propulsion and auxiliary machinery at optimum efficiency

c. An increase in shaft r/min in excess of 5 percent to maintain a given speed.

081–2.1.6.1 There are other performance parameters that may indicate excessive fouling. For steam–propelled ships, an increase in main turbine first stage shell pressure needed to maintain a given shaft r/min can generally be attributed largely to hull or propeller fouling assuming a constant main condenser vacuum and main steam supply pressure and temperature). For ships equipped with main shaft torsion–meters, an increase in torque at a given shaft r/min may also indicate the need for cleaning. There are, however, other explanations for deterioration in any performance parameter and it is therefore imperative that an underwater hull inspection be conducted before initiating any cleaning.

081–2.1.7 DIVER INSPECTION. In addition to observing the ship performance indicators and conducting precleaning inspections, the Commanding Officer should take advantage of any other scheduled underwater hull inspections to observe the condition of the antifouling paint as well as the degree and type of hull fouling. These inspections should be documented as outlined in paragraph 081–2.2. Postcleaning inspections, preferably by the same diving team, should immediately follow the cleaning evolution. These ensure adequate quality control of the cleaning operations and identify any hull or paint damage that may have been hidden by the fouling.

081–2.1.8 CLEANING ASSESSMENT. The decision to clean any individual hull which shows signs of a failing paint system requires a thorough assessment of that hull's cleaning history. An informative assessment of a ship's underwater hull condition cannot be made if the hull fouling is FR–60 or greater. In this case, the decision to not clean must be weighed against the importance of a thorough hull inspection. Normally, the risks associated with additional cleaning are justified by the necessity of performing an unobstructed inspection to allow a thorough compilation of hull system conditions and facilitate intelligent maintenance planning.

081–2.1.8.1 Should areas of significant paint failure be discovered during a precleaning or postcleaning hull inspection, the painted areas of the hull shall not be subjected to further cleaning without specific Type Commander (TYCOM) approval. A guide for assessing risk to failing paint is provided in Table 081–2–1. Assistance in determining severity of failure and hull protection is provided in paragraph 081–2.1.9, Table 081–1–2, and Figure 081–1–2.

081–2.1.9 HULL PROTECTION SYSTEMS. The two systems which protect a ship's hull from corrosion deterioration are the anticorrosive paint system and the impressed current or sacrificial anode cathodic protection system. The interaction of these two systems and their ability to adequately protect the hull from corrosion is interdependent on several factors. Because hull cleaning inspections reveal the most comprehensive information on these system activities, thresholds are provided which indicate marginal or failing hull protection systems. The threshold for ships outfitted with impressed current cathodic protection systems is 10 percent bare metal observed on the underwater hull. Thresholds for ships with sacrificial anode systems are 5 percent bare metal or an observation of any inactive anodes. For ships with sacrificial anode systems, a hull potential survey should be conducted whenever either of these thresholds is observed.

081–2.2 DOCUMENTATION

081–2.2.1 GENERAL. In addition to the obvious fuel savings benefits realized by an underwater hull cleaning program an equally important benefit is the underwater hull condition data compiled before, during, and after cleaning operations. The time spent during a cleaning operation is the most comprehensive inspection of a ship's underwater body. By its very nature hull cleaning requires the diver to look at every square foot of the underwater hull and it is therefore imperative that the complete underwater hull condition be documented after a cleaning operation. Contractor and Navy diving activities must report the observed conditions on identical forms so that the data obtained from individual inspections can be compiled to produce meaningful trends. The NAVSEA forms identified herein should be used to document all underwater hull inspections. All entries must be completed on the forms. If conditions will not permit the inspection of a particular area, that fact should be so noted on the form. Before commencing cleaning operations, the type, degree, and distribution of fouling present will be documented. Hull condition documentation will be provided when cleaning has been completed. Paragraph 081–2.2.1.1 will be adhered to when providing documentation. Documentation for cleaning efforts accomplished by activities other than the NAVSEA Hull Cleaning Contractor must be forwarded to NAVSEA Code 00C.

a. NAVSEA 4730/3 (NSN 0116–LF–047–3020) **Diver Hull Inspection Data**

b. NAVSEA 4730/4 (NSN 0116–LF–047–3025) **Sonar Dome Rubber Window Inspection Data**

c. NAVSEA 4730/5 (NSN 0116–LF–047–3030) **Sonar Keel Dome Inspection Data**

d. NAVSEA 4730/6 (NSN 0116–LF–047–3035) **Propeller Inspection Data**

e. NAVSEA 4730/7 (NSN 0116–LF–047–3040) **Impressed Current Cathodic Protection Inspection Data**

f. NAVSEA 4730/8 (NSN 0116–LF–047–3045) **Auxiliary Propulsion Units Inspection Data**

Table 081–2–1. OBSERVED HULL CONDITIONS AND RECOMMENDED ACTIONS

Schedule of Inspection	Observation of Underwater Hull*	Action Options	Consequences
6 months from undocking	No serious blistering	Clean hull when required	None
	Significant unbroken blisters	Recognize ship as possible future risk	None
Prior to first underwater cleaning	No serious blistering but some hull fouling (FR–60 or greater)	Clean hull	None
	Significant blistering and some hull fouling (FR–60 or greater)	Clean hull –or–	Possibility of rupturing blisters, increasing corrosion and refouling
		Do not clean hull	Reduce chance of corrosion; increasing fuel penalty due to continued fouling
	Paint not visible due to fouling	Clean hull	If no blisters, no danger; if blistered, possibility of rupturing blisters, increasing corrosion and refouling
After first cleaning	Wear of paint on edges and welds; no blisters	Reinspect prior to next cleaning	None
	Significant unbroken blisters	Reinspect prior to next cleaning	Possibility of rupturing blisters with future cleaning
	Significant ruptured blisters and rust staining	Remove ship from cleaning program and plan near-term drydocking to repair paint –or–	If drydocked quickly, none –or– If drydocking is postponed, increased fuel penalty due to fouling or corrosion
		Continue scheduled cleanings; no drydocking	Moderate fuel penalty; but increasing hull corrosion
Prior to second cleaning	No serious blistering but hull continuing to foul	Clean hull	None
	Significant unbroken blistering, increased fouling growth (rating of 60 or greater)	Clean hull –or–	Possibility of rupturing blisters, resulting in increased corrosion and refouling
		Do not clean hull	Reduced corrosion; fuel penalty due to fouling
	Paint not visible due to fouling	Clean hull	Depends on paint condition at post-cleaning inspection

Table 081–2–1. OBSERVED HULL CONDITIONS AND RECOMMENDED ACTIONS (Continued)

Schedule of Inspection	Observation of Underwater Hull*	Action Options	Consequences
After second cleaning	Continuing paint wear on edges and welds, no blisters	Reinspect prior to next cleaning	None
	Significant unbroken blisters	Reinspect prior to next cleaning	Possibility of rupturing blisters during future cleanings
	Significant ruptured blisters and corrosion	Remove ship from cleaning program and plan near term drydocking to repair paint	If drydocked quickly, none –or–
		–or–	If drydocking is postponed, increased fuel penalty due to fouling of failed point or increasing hull corrosion
		Continue scheduled cleanings; no drydocking	Significant fuel penalty due to rapid refouling will require increased cleaning –and– Serious corrosion may exceed capacity of cathodic protection system to control
After subsequent cleanings	Continued wear of paint, but major flat areas intact	Clean hull	Increase refouling rate and cleaning frequency to maintain performance
			Should consider interim drydocking based on expected mission requirements and paint life
	Large areas of failed paint due to broken blisters, peeling, or wear	Schedule interim drydocking at earliest possible time	Ship will be restored to good condition in drydock

*Observations to be conducted by Navy/commercial diver experienced in underwater paint observations.

081–2.2.1.1 In addition to the NAVSEA forms identified in paragraph 081–2.2.1, the surveys described in paragraphs 081–2.2.2 through 081–2.2.2.2 should be documented using color still photography or underwater color television systems when unusual damage or fouling is noted. These methods of fouling documentation are described in more detail in paragraphs 081–2.2.3 through 081–2.2.4.1. Photographic services should be requested through local Intermediate Maintenance Activities (IMA's), Readiness Support Groups (RSG's), or Mobile Diving and Salvage Units (MDSU's).

081–2.2.2 SURVEY PLAN. A Survey Plan is recommended to ensure that documentation of fouling conditions and damage includes critical areas of the underwater body. Use the ship Drydocking Drawing in preparing the Survey Plan, since it provides the principal dimensions and the locations of easily recognized underwater hull components.

081–2.2.2.1 In particular, the following areas should be identified on the Survey Plan and shall be inspected and documented for both fouling and damage during each precleaning and postcleaning inspection:

a. All sonar domes or unpainted surfaces (particularly propellers and masker belts)

b. All protruding appendages (that is, bilge keels)

c. Cathodic protection systems; zincs, impressed current anodes, references cells, and dielectric shields

d. Junctions of hull surface with struts, stern tubes, sonar dome, and other appendages

e. Keel block and side block areas from last drydocking

f. Sea chests, ballast tanks, and hull openings

g. Previously identified damaged areas.

081–2.2.2.2 A Survey Plan for surface ships is shown in Figure 081–2–1. A representative Survey Plan for a submarine, with the different locations defined, is shown in Figure 081–2–2.

081–2.2.3 UNDERWATER TELEVISION SYSTEMS. The Divers Underwater Color Television System (DUCTS) may be used to transmit color video description to topside personnel during the survey, and for pictorial documentation of the hull. Television systems approved for fleet use are listed in NAVSEAINST 10560.2, **Diving, Equipment Authorized for Navy Use.**

081–2.2.3.1 Underwater television systems provide quick on–the–spot assessment of fouling conditions. The taped transmission should be retained for comparison with the results of the next survey. Black and white video does not allow accurate evaluation of paint condition nor quality of cleaning. Black and white television systems are adequate to identify general fouling density and distribution; however, to adequately assess hull cleaning effectiveness, hull damage, and paint condition, color television systems are required. For correlation purposes, visual documentation after cleaning should depict the same areas and special features as documentation before cleaning. Good coverage requires that the television operator make a series of passes at 6 foot intervals. During the use of the various systems, two–way communication between the topside decision maker and the diver shall be used to identify paint color and surface condition to supplement video transmission. A scale and color reference indicator shall be used to assist in the analysis of the video transmission. The video tape should include ship name, hull number, location or component on the hull, and the date.

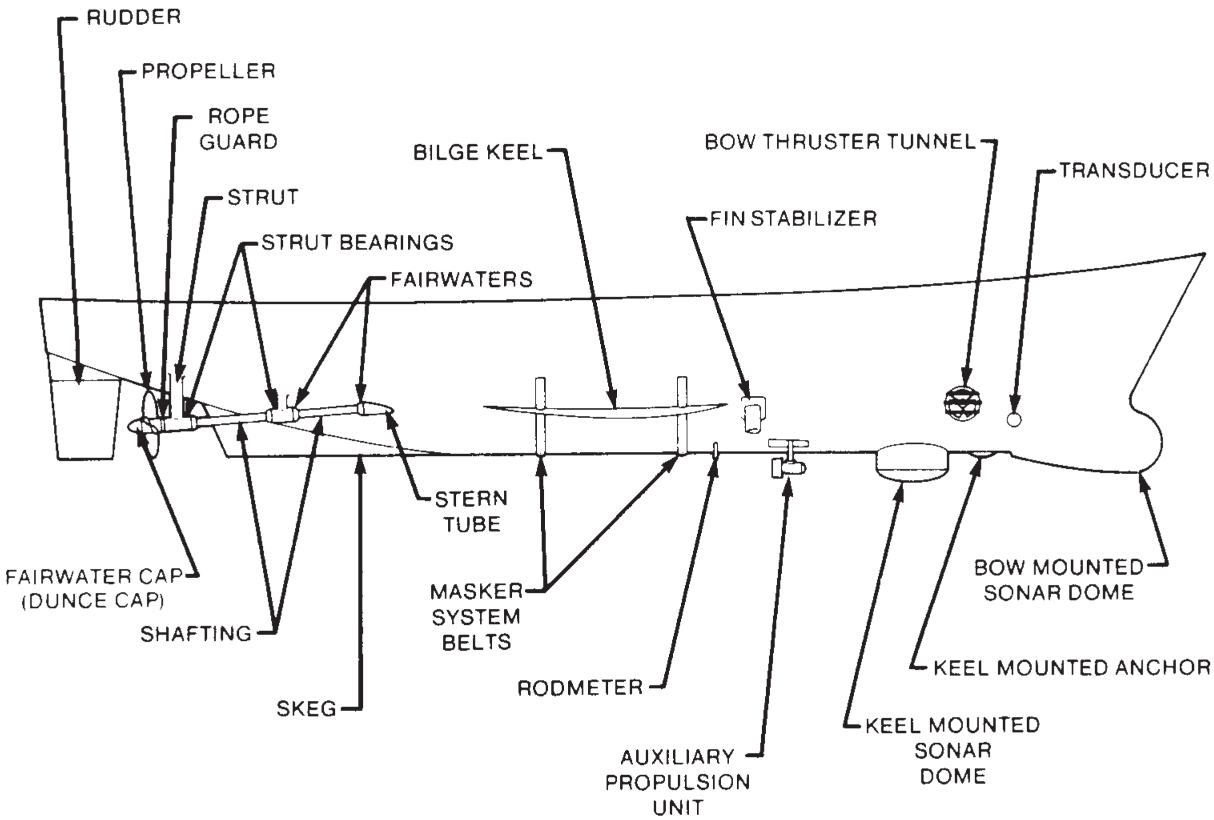
081–2.2.4 PHOTOGRAPHY. Whenever underwater still photographic equipment is available, color photographs of all areas of interest should be obtained to provide identification of fouling type, density, and distribution, as well as verification of properly cleaned surfaces (as identified in paragraphs 081–2.3 through 081–2.3.3).

081–2.2.4.1 Photographs will be identified with the ship name or hull number, the location or component on the ship, and the date. A size scale and color reference indicator shall be used in each photographic view.

081–2.2.5 WATER CONDITIONS. In most Navy ports, little can be done to control water conditions. If a choice exists however, expedite cleaning by choosing the area of clearest water. A slight current, on the order of one–half knot, is desirable to carry debris away from the worksite during cleaning. Cleaning in currents over two knots shall be avoided, unless dictated by operational necessity.

081–2.3 CRITERIA FOR A CLEANED HULL SURFACE

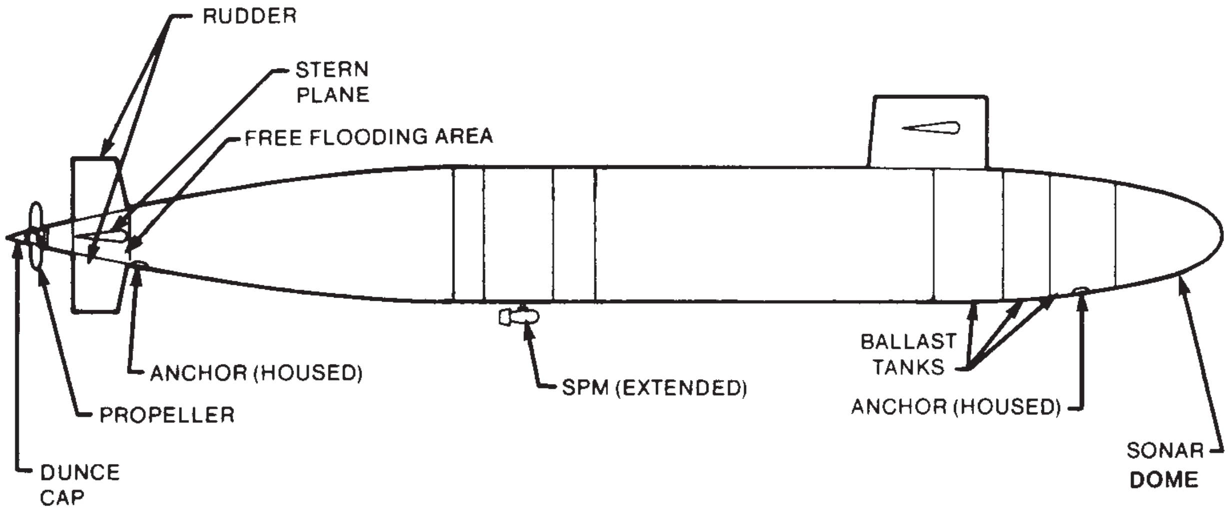
081–2.3.1 The purpose of underwater hull cleaning is to remove fouling and to restore or rejuvenate the effectiveness of the antifouling paint. The underwater cleaning process, therefore, should remove all traces of biological fouling. The green chemical layer of the non–ablative vinyl antifouling paint will become harder to remove as the paint system ages. This layer of cuprous oxide is nontoxic and will not prevent marine growth from adhering to the surface. The degree of removal of this green layer is proportional to the age of the paint system and the time between cleanings. Cleaning should partially remove the green chemical layer to expose a mottled pattern of 40 to 60 percent red antifouling paint.



NOTES:

1. IN ADDITION TO THE ABOVE APPENDAGES, THE CONDITION OF THE HULL PLATING (FOULING AND PAINT SYSTEM) SHOULD BE NOTED FOR THE BOW AREA, STERN AREA, FLAT BOTTOM, SIDES, BOOTTOPPING, AND DOCKING BLOCK . BEARING AREAS.
2. NOTE CONDITION OF ZINC ANODES, IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM ANODES AND REFERENCE CELLS.
3. NOTE CONDITION OF SEACHESTS/HULL PENETRATIONS.
4. PHOTOGRAPHS SHOULD BE TAKEN BEFORE AND AFTER CLEANING AND ANNOTATED IN ACCORDANCE WITH THE ABOVE NOMENCLATURE.

Figure 081–2–1. Example of Survey Plan for Surface Ships.



NOTES:

1. IN ADDITION TO THE ABOVE APPENDAGES, THE CONDITION OF THE HULL PLATING (FOULING AND PAINT SYSTEM) SHOULD BE NOTED FOR THE BOW AREA, STERN AREA, BOOTTOPPING, HULL AREA BELOW BOOTTOPPING, AND DOCKING BLOCK BEARING AREAS.

2. NOTE CONDITION OF ZINC ANODES.

3. NOTE CONDITION OF SEACHESTS/HULL PENETRATIONS.

4. PHOTOGRAPHS SHOULD BE TAKEN BEFORE AND AFTER CLEANING AND ANNOTATED IN ACCORDANCE WITH THE ABOVE NOMENCLATURE.

Figure 081–2–2. Example of Survey Plan for Submarines.

081–2.3.2 Cleaning the non-ablative vinyl anti-fouling paint to alternate mottled pattern and continuous red will allow rejuvenation of antifouling (AF) paint with minimum damage to intact AF paint and prevent the formation of a tough insoluble layer over the AF paint. Progressive paint deterioration from a properly cleaned hull with the mottled pattern to a hull with advanced corrosion is described in Table 081–1–2. Examples are illustrated in Figure 081–1–2.

081–2.3.3 The lower portion of a submarine hull from maximum beam to keel is normally painted with red formula 121 AF paint, and the cleaning criteria in paragraphs 081–2.3.1 and 081–2.3.2 will apply. However, in the area from maximum beam to maximum load line, black formula 129 AF is normally used. There is usually no green chemical layer formed on formula 129 AF paint; therefore, removal of the green slime layer cannot be used as a cleaning criterion. This lack of visual criterion requires exercising of great care to prevent removal of excessive amounts of formula 129 AF paint. Removal of the heavy slime layer will expose a black hull. A mottled pattern on this hull paint system is not desirable, as this indicates removal of paint exposing different colored anticorrosion paint.

081–2.3.4 Ablative and self–polishing antifouling paints do not generate a green chemical layer of cuprous oxide. When properly cleaned with the least aggressive brush to remove all biofouling, a bright red surface (or black surface on boot tops and submarine hulls above the maximum beam) should be present. Below the boot top on surface ships, repeated cleanings will yield a mottled pattern of the red antifouling paint and a black (second) layer of antifouling paint. Suspend cleaning and contact NAVSEA Code 00C when this mottled pattern appears and document the coating condition as specified in section 081–2.2.

081–2.4 CRITERIA FOR A CLEANED PROPELLER SURFACE

081–2.4.1 The purpose of underwater propeller cleaning and polishing is to remove fouling and provide a smooth polished surface. Therefore the underwater cleaning process should remove all traces of barnacle basal plates. Propeller polishing should follow the cleaning process to remove all calcium deposits and produce a polished finish (Rubert Scale A or B).

081–2.5 CRITERIA FOR A CLEANED PROPULSION SHAFT SURFACE

081–2.5.1 The purpose of underwater cleaning of the propulsion shaft is to remove all biofouling, produce a smooth surface, and facilitate inspection of the shaft for any indications of damage (i.e., fiberglass disbondment, cracks in the coating and possible corrosion and pitting of the underlying metal shaft). The cleaned shaft will be red in color (for ablative antifouling paints), or red to mottled red (for non-ablative vinyl antifouling paints). A clean fiberglass shaft with no remaining paint will be white in color.

SECTION 3.
OPERATIONS

CAUTION

Do not attempt to clean hulls coated with ablative antifouling paints (paragraph 081–2.1.4). Consult the latest Docking Report to determine the type of antifouling coating on a ship's hull or contact NAVSEA Code 00C.

081–3.1 GENERAL

081–3.1.1 Navy diving operations will be conducted in accordance with NAVSEA 0994–LP–001–9010, **U.S. Navy Diving Manual,** supplemented by local base and Senior Officer Present Afloat (SOPA) instructions. All standard and local safety precautions will be observed. Prior to any cleaning operation, observe the diver precautions and warnings of paragraphs 081–3.2 and 081–3.2.1. Postdive precautions are provided in paragraph 081–3.3. If contractor services are being used, the contractor shall conduct such operations in accordance with OPNAVINST 3150.27, **Navy Diving Program.** Navy and commercial cleaning equipments are described in section 4.

081–3.2 PREPARATION

081–3.2.1 For diver safety and efficient cleaning operations:

a. The ship shall be breasted out a minimum of 4 feet from the pier and clear on the outboard side. In the case of aircraft carriers, the ship shall be breasted out a minimum of 20 feet.

b. There shall be sufficient depth of water under the keel, a minimum of 6 feet at Mean Low Water (MLW).

c. The underwater hull shall be free of obstruction.

d. Retractable speed log rod–meters must be in the fully raised position. On those ships with fixed rod–meters, mark the locations with visual or auditory warning devices.

e. Main and auxiliary circulating pumps shall be secured.

f. No cofferdams or other obstructions that would impede the cleaning operations may be attached to the hull.

CAUTION

It is important that the impressed current cathodic protection system be reenergized after cleaning to prevent corrosion.

g. The impressed current cathodic protection system on the ship being cleaned shall be deenergized and the limits of the dielectric shield shall be marked with visual or auditory warning devices to enable the cleaning personnel to keep the cleaning equipment clear of the shield and anodes.

h. The limits of submarine bow sonar domes or rubber–coated surfaces shall be marked with visual or auditory warning devices to enable the cleaning personnel to keep self–propelled multi–brush cleaning vehicles clear of these areas.

i. The most recent Docking Report shall be available.

j. When contractor divers are engaged in hull cleaning of nuclear ships, they will be trained in accordance with NAVSEA 0389–LP–015–3000, **Radiological Controls, Nuclear Propulsion Plant.**

k. Prior to contractor diving on nuclear ships, a hull survey of the ship shall be conducted in accordance with NAVSEA 0389–LP–015–3000 using Navy divers. The surveys shall determine extent, if any, of hull surface contamination. Areas with contamination must be marked in such a way that the contractor divers can avoid them.

l. Prior to diving on nuclear ships, contractor divers will be given a briefing covering the requirements of NAVSEA 0389–LP–015–3000. Hull surveys performed in accordance with the previously mentioned manual shall be discussed as part of this briefing. Completion of this briefing shall be documented by completing a signature block on the diving permit and at that time dosimeters (TLD) shall be issued to contractor divers.

m. Active sonars shall be operated in accordance with NAVSEAINST 3150.2, **Safe Diving Distances from Transmitting Sonars,** during cleaning operations.

CAUTION

Do not attempt to clean hulls coated with fouling release coating systems. Consult the latest Docking Report to determine the type of antifouling coating on a ship's hull. Should a hull coated with a fouling release coating require cleaning, see paragraph 081–2.1.5.

081–3.3 HULL CLEANING

081–3.3.1 Routine hull cleaning will be accomplished using only approved materials as described in section 4.

CAUTION

Self–propelled multi–brush cleaning vehicles are forbidden on rubber or glass reinforced plastic (GRP) domes or any other rubber–coated surfaces; nor is it permissible to drive such machines across these surfaces.

CAUTION

The use of **barnacle busters** or similar devices is prohibited.

NOTE

The cleaning guidance provided in paragraphs 081–3.5.2 through 081–3.5.6 applies only to painted surfaces and appurtenances. Cleaning guidance for propellers, sonar domes, masker belts, prairie air systems, and sea chests is provided in paragraphs 081–3.5.2 through 081–3.5.7.

081–3.3.2 Where convex hull curvature permits (radius of curvature 10 feet or greater), self–propelled cleaning vehicles may be used. The brushes used on these units shall be in good condition and conform to the characteristics listed in Table 081–3–1. All rotating brushes shall be turned off or retracted off the hull during idle periods when the machine is resting on the hull as well as when the machine is being turned on the hull at the end of each swath.

081–3.3.3 In areas of smaller convex curvature, areas of concave curvature (such as found between the skeg and the ship's bottom) and areas of limited access, hand–held rotary brushes are permissible. The brushes used on these units shall be in good condition and conform to the characteristics listed in Table 081–3–1.

081–3.3.4 For hand–held rotary brush equipment brush A–1 or A–2 should be used to remove fouling in fouling rating (FR) categories FR–10 to FR–30. Brush C should be used to remove fouling in rating categories FR–40 to FR–100. For self–propelled multi–brush cleaning vehicles, the least aggressive brush necessary to achieve a properly cleaned surface shall be used. The brushes are arranged in Table 081–3–1 from the most aggressive brush (E–1) to the least aggressive brush (E–4). Brushes E–4 and E–3 should be used for routine cleanings. Brush E–4 should be used to clean FR–10 to FR–30. Brush E–3 should be used to clean FR–40 to FR–60. Brush E–2 should be used to clean calcareous fouling (FR–60 to FR–100). Brush E–1 should be used to clean severe calcareous fouling only after attempts to clean using brush E–2 have failed. **Paint damage can result from improper use.**

Table 081–3–1. BRUSH/DISK CHARACTERISTICS

Brush /Disk Type	Plate Dia-meter (in)	Material	Bundle Dia-meter (in) at Plate*	Quantity and Ar-rangement of Bundles	Bundle Length in inches and Angle (degree**)	Rockwell Hartness	Abra-sives Grit Size	Abra-sives Thick-ness (in)	Non–Woven Nylon Mesh Matrix
A–1	14	Nylon, .03 dia bristle, 52 per bundle.	.25	7 rows: inner row has 36, increases by 6 per row (378 total).	1.00 (90)	R108–120	N/A	N/A	N/A
A–2	9	Polypropylene, .110 dia bristle, 9 per bundle	.375	1 row of 12, 1 row of 18, and 1 row of 24.	1.870(70) 2.375(70) 2.625(70)	N/A	N/A	N/A	N/A
A–2	11	Polypropylene, .110 dia bristle, 9 per bundle	.375	1 row of 23, 1 row of 32, and 1 row of 36.	2.375(70) 2.563(70) 2.875(70)	N/A	N/A	N/A	N/A
A–2	13	Polypropylene, .110 dia bristle, 9 per bundle	.375	1 row of 27, 1 row of 31, and 1 row of 36.	2.125(85) 2.50(80) 2.75(75)	N/A	N/A	N/A	N/A
C	13	Steel, .14 x .02 in flat wire, 5 per bundle.	.375	1 row of 18, 1 row of 24, and 1 row of 36.	1.75(90) 1.75(90) 1.75(90)	C–41	N/A	N/A	N/A
D	5/7/12	Silicon carbide in nylon	.06	N/A	1.00(90)	N/A	46	N/A	N/A
D3	7.5 or 9	Silicon carbide	N/A	N/A	N/A	N/A	36-40	1	Dense
D5	7.5 or 9	Silicon carbide	N/A	N/A	N/A	N/A	36-40	1	Rigid Dense
E1	22	Galv steel 7 x 19 wire, w/copper ferrules***	.1875	1 row of 60 and 1 row of 60.	6.00(50) 6.50(50)	N/A	N/A	N/A	N/A
E2	22	Galv steel 7 x 19 wire	.1875	1 row of 60 and 1 row of 60.	6.00(50) 6.50(50)	N/A	N/A	N/A	N/A
E3	23	Polypropylene, .125 dia bristle, 9 per bundle	.3125	1 row of 60, 1 row of 60 and	6.00(50) 6.75(50)	N/A	N/A	N/A	N/A
		Galv steel 7 x 19 wire****	.215	1 row of 32 and	7.50(50)	N/A	N/A	N/A	N/A
		Galv steel 7 x 19 wire****	.265	1 row of 16.	7.50(50)	N/A	N/A	N/A	N/A
E4	23	Polypropylene, .125 dia bristle, 7 per bundle	.3125	1 row of 80, and 1 row of 80.	600(50) 6.50(50)	N/A	N/A	N/A	N/A

* Bristles are compressed into each hole.
** Bundle angles are measured from backing plate to the bristles.
*** Brush E–1, Copper ferrules (15 max. per brush) are evenly spaced and join the ends of two bristles together (from separate rows).
**** Brush E–3, TIG weld the end of each wire to prevent fraying.

081–3.3.5 All marine fouling will be removed from painted surfaces along with a sufficient amount of the chemical surface layer which forms on antifouling (AF) formula 121 so that a mottled pattern of the red AF paint is visible interspersed with the green. Extreme caution should be exercised to prevent damage to the paint. A properly cleaned painted surface is described in paragraphs 081–2.3 through 081–2.3.3.

081–3.3.6 All marine fouling will be removed from surfaces coated with ablative or self–polishing paints so that a bright red or black surface should be present. On subsequent cleanings of ablative and self–polishing paints, a mottled pattern of red and black (representing the second coat of antifouling paint) will be obtained. Extreme caution should be exercised to prevent damage to the paint; the paint should be cleaned with the least aggressive brush necessary to achieve a properly cleaned surface, as described in paragraph 081–2.3.4

081–3.4 CATHODIC PROTECTION SYSTEMS

081–3.4.1 Warning devices (audible or visible) shall be placed in the vicinity of impressed current anodes, reference cells, and dielectric shields to guard these items against damage during the cleaning operation. The location of these items should be obtained from the ship's engineer prior to commencing the cleaning operation. The calcium deposit formed on the dielectric shield must be preserved. The shield area is approximately 16 feet wide by 13 feet high with the anodes located in the geometric center. Cleaning of the impressed current anodes is forbidden. Zinc anodes are to be cleaned.

081–3.5 CLEANING GUIDELINES

081–3.5.1 GENERAL. The following paragraphs provide guidelines for cleaning propellers, sonar domes, masker emitter belts, prairie system components, sea chests, submarine hulls, wood and fiberglass hulls and propulsor shafts.

081–3.5.2 PROPELLER CLEANING. Propeller cleaning will be accomplished using only approved materials as described in Section 4.

CAUTION

Use only the most experienced personnel when cleaning the outer 6–inch periphery of propeller blades. These personnel should be familiar with propeller blade edge geometry. Brush C shall not be used to clean the outer 6–inch periphery of propeller blades.

CAUTION

At no time should high–pressure water jets being used on propeller surfaces be allowed to operate at pressures above 10,000 pounds per square inch gage (lb/in^{2}g).

NOTE

For convenience in identification, the abrasive disks have been labeled D3 and D5 (Table 081–3–1). Characteristics of the two abrasive disk configurations which have been authorized for use on powered hand–held rotary brush units are listed in Table 081–3–1. Disk procurement data is listed in Table 081–3–2.

081–3.5.2.1 The geometry of the propeller blade leading edges, trailing edges, and tips is critical. To prevent damage to these critical areas, no metal tools or devices shall be used for cleaning the outer 6–inch periphery of propeller blades. Otherwise, it would be possible to change the propeller's acoustic signature, induce singing, or induce cavitation. Brass, hard plastic, or wooden scrapers, nylon and silicon carbide impregnated nylon brushes, silicon carbide marine cleaning disks, and authorized high–pressure water jets may be used to clean all areas of all propeller blades including the outer 6–inch periphery. Brush C shall not be used on the outer 6–inch periphery of any propeller blades. When cleaning the outer 6–inch periphery of propeller blades, the brushes and disks must be kept flat on the propeller surface. Do not attempt to round the edges of the propeller blade with brushes and disks. Multi–brush units shall not be used on propeller surfaces.

081–3.5.2.2 For effective cleaning of a propeller with a fouling rating of FR–50 and above, the upper calcareous wall structure is best removed using a brass scraper or high–pressure water jet which severs it from the basal plate. The basal plate is then removed, and the surface polished, by using brush D or abrasive disk D3 or D5. For light growth, FR–40 and less, effective cleaning can be accomplished in a one–step process using brush D or abrasive disk D3 or D5. The abrasive disks must be kept moving across the surface of the propeller to ensure a clean and smooth surface.

NOTE

Any suspected use of wire brushes on the outer 6–inch periphery of propeller blades must be documented and reported to the Type Commander.

To regain maximum propeller efficiency, remove as much of the barnacle basal plate as possible without damaging the propeller surface.

Table 081–3–2. BRUSH/DISK AND PROPELLER GAUGE PROCUREMENT DATA

Equipment Type	Mfg Stock No./Product Name	Typical Manufacturer
Brush A–1	D18–ST–585	Zimmerman Brush Co. 900 West Lake St. Chicago, IL 60607 (312) 829–3262
Brush A–2	9” –AP–0900–A2 11” –AP–1100–A2 13” –AP–1300–A2	Sea Brush Mft. P. O. Box 2211 Spring Valley, CA 91977 (619) 670–5898
Brush C	JP–1300–C	Sea Brush Mft. P. O. Box 2211 Spring Valley, CA 91977 (619) 670–5898
Brush D	5” –05121 7” –05241 12” –05541	Abtex Corporation P. O. Box 188 Dresden, NY 14441 (315) 536–7403
Disk D3	Scotch–Brite, Marine Cleaning Disk– 3 Density 7.5” –48011–04417 9” –48011–04418	3M Company St. Paul, MN 55144
Disk D5	Scotch–Brite, Marine Cleaning Disk– 3 Density 7.5” –48011–04239 9” –48011–04240	3M Company St. Paul, MN 55144
Ruperts’ Gauge	Propeller Roughness Comparator Scale	Rubert & Co. Ltd. Demmings Road Cheadle, Cheshire England 4461–428–6058

NOTE: The brush procurement data presented in Table 081–3–2 is provided only to assist in describing the authorized cleaning equipment. Brushes and disks may be procured from any other manufacturer/distributor provided that the characteristics of Table 081–3–1 are met.

NOTE

Although approved for limited use on propellers, brush C should be used only as a last resort by a highly trained diver to remove severe fouling. Because of its configuration, brush C can cause scratches and gouges on propeller surfaces if used by an inexperienced diver. Brush C shall not be used to clean the outer 6–inch periphery of propeller blades.

WARNING

081–3.5.3 SONAR DOME CLEANING. Sonar dome cleaning will be accomplished using only approved materials as described in section 4.

CAUTION

Self–propelled multi–brush cleaning vehicles are forbidden on rubber or GRP sonar domes or any other rubber–coated surfaces; nor is it permissible to drive such machines across these surfaces.

081–3.5.3.1 Surface ship bow and keel mounted **no–foul** rubber sonar domes (Figure 081–3–1 and Figure 081–3–2) and rubber–coated surfaces (Figure 081–3–3) may be cleaned using hand–held rotary brush units employing brush A–1 or disk D3. Submarine GRP sonar domes may be cleaned using brush A–1 only. Extreme caution shall be exercised when cleaning these surfaces to prevent scratches or damage to the sonar dome or rubber–coated surface. Bowmounted steel sonar domes may be cleaned using brush C.

081–3.5.3.2 On both rubber and GRP domes, heavy barnacle growth should first be broken down using wooden or plastic hand–held scrapers. Disk D3 must be used with caution and kept in flat contact with the rubber surface. **Do not allow disk D3 to operate on edge.** Difficulty in handling the rotary brush unit due to excessive bouncing and chattering of disk D3 when in contact with the rubber surface is typically caused by low revolutions per minute. A Stanley Model GR–24 hydraulic grinder operating at 2,000 pounds per square inch (lb/in^2) and 9 gallons per minute (gal/min) has proven most effective for sonar dome cleaning and is recommended. If any signs of damage to the sonar dome caused by cleaning are noted, discontinue dome cleaning immediately and notify NAVSEA.

081–3.5.4 MASKER AIR EMITTER BELT CLEANING. Masker emitter belt cleaning will be accomplished using only approved materials as described in Section 4.

CAUTION

Prior to cleaning the masker air system, the hull isolation valves **must** be secured.

081–3.5.4.1 This cleaning is a three step process which will improve the performance of the masker belts; however further cleaning as outlined in the ship's Maintenance Requirement Cards (MRC's) will be required to optimize the masker belts' performance. Experience has shown that each of these processes is equally important and serves several distinct cleaning objectives. These steps can neither be done in random order, nor consolidated.

081–3.5.4.2 Remove marine growth and calcium from the external surfaces of the masker belt using a hand-held rotary brush unit equipped with brush C for **painted masker belts** or brush C, disk D3 or D5 for **Unpainted copper-nickel masker belts.** Caution must be exercised to avoid contacting epoxy and/or painted edges with the brush or disk.

081–3.5.4.3 Internal surfaces of the belts should be cleaned using a 10,000 lb/in^{2}g flexible lance to remove all fouling and calcification that has accumulated. The lance should be inserted into the cleanout opening at a rate of one foot per minute (FPM) until the lance has traveled five feet. Once this distance is reached, the lance should be retracted at the same continuous rate. Several passes of the lance will be required until this five foot section is thoroughly clean. During retraction, debris will be expelled from the cleanout opening until the interior surfaces are clean. Once the section is clean, proceed to insert the lance to the next increment.

WARNING

Any damage (i.e., dents, crushing, or twisting) to the belt could interfere with the ability of the lance to be inserted and could cause the lance to become lodged inside. Therefore a precise measurement of any damage from the cleanout plug is mandatory. The lance should be clearly marked to prevent the lance form being inserted beyond the point of damage.

081–3.5.4.4 Marine fouling and calcification that restricts the emitter holes can be removed by external hydroblasting the individual holes using the 10,000 lb/in^{2}g zero thrust gun. With an eductor installed in the cleanout opening and operating, hydroblast each of the holes until they are clean. Caution must be exercised to avoid contacting epoxy and/or painted edges with the high pressure water stream.

081–3.5.4.5 Upon completing the external hydroblasting, conduct a visual inspection of the belts to determine cleanliness. This can be accomplished by divers' supplying fresh water through the cleanout opening or by ship's force supplying bleed air to the belt. By using either test, divers can visually verify the flow out of the emitter holes.

CAUTION

Before pressurizing the masker emitter belt with fresh water, ensure that the masker emitter shut off (isolation) valve is secured. This valve is located prior to the hull penetration for the emitter belt supply line.

081–3.5.4.5.1 Flow Check Using Fresh Water. Connect the fresh water supply line to the cleanout opening and supply 35 lb/in^{2}g water. Examine each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the external hydroblasting.

CAUTION

During the initial activation of the masker air system, divers should stand clear of the emitter system until the air has been adjusted to a low flow rate. Otherwise the diver could by blown off the system and up to the surface.

081–3.5.4.5.2 Flow Check Using Bleed Air. Have the ship light off the masker air systems and adjust the flow to a bleed. Once flow rate has stabilized, the diver examines each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the external hydroblasting.

081–3.5.5 MASKER AIR EMITTER HUB CLEANING. The hub air systems are located on the rope guards and fairwaters of the main struts on various ship classes.

081–3.5.5.1 This cleaning is a three step process which will improve the performance of the hub air system. However, further cleaning as outlined in the ship's Maintenance Requirements Cards (MRC's) will be required to optimize the masker system's performance. Experience has shown that each of these processes is equally important and serves several distinct cleaning objectives. These steps can neither be done in random order, nor consolidated.

CAUTION

Prior to cleaning the air system, the hub masker air supply hull isolation valves must be secured.

081–3.5.5.2 Remove marine growth and calcium from the tops of the emitter holes on the rope guards and fairwaters. Brush D should be used for rope guards and fairwaters with emitter holes drilled directly into the rolled plating. Disk D3 or D5 should be used on copper-nickel nozzles which have emitter holes drilled into the nozzle. Brush A-1 or A-2 should be used on teflon nozzles.

081–3.5.5.3 Marine fouling and calcification within the air supply tube can be removed by using a 2,500 lb/in^{2}g flexible lance inserted into the cleanout openings. These openings are found at the top and bottom of the rope guards and fairwaters and should have a plug installed. If extreme corrosion exists around a plug and damage could occur, do not attempt removal; inform the ship and the Navy's Fleet hull cleaning representative, and proceed with the external hydroblasting. Some rope guards are installed in two halves which may be connected internally with flexible hoses and fittings that will prevent the lance from passes to the other half. Clean both inboard and outboard sides of the supply tube and then transfer to the other cleanout opening to clean the other half.

Do not internally hydrolance if the masker air nozzles are teflon.

081–3.5.5.4 Marine fouling and calcification that restrict the emitter holes can be removed by external hydroblasting the individual holes using the 10,000 lb/in^{2}g zero thrust gun. With an eductor installed in the cleanout opening and operating, hydroblast each of the holes until they are clean. When two cleanout openings are available, install the eductor on the lower opening. Caution must be exercised to prevent the high pressure water jet from contacting the painted surfaces around the holes and nozzles.

Do not externally hydroblast if the nozzles are teflon.

CAUTION

During the initial activation of the masker air system, divers should stand clear of the emitter system until the air has been adjusted to a low flow rate. Otherwise the diver could by blown off the system and up to the surface.

081–3.5.5.5 Have the ship light off the masker air systems and adjust the flow to a bleed. Once flow rate has stabilized, the diver examines each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the cleaning process.

081–3.5.6 PRAIRIE AIR EMITTER CLEANING. On ships outfitted with prairie air systems, air emitter holes are located near the edge of each fin stabilizer and on propeller blade edges.

CAUTION

Do not attempt to clean prairie air emitter holes without a minimum of 10 feet of water below the lowest emitter hole (propeller or stabilizer). Lacking cleanout plugs, this system will ingest stirred up silt from the shallow bottoms when air is secured after cleaning, resulting in clogged internal piping. System shall not be cleaned without prairie air operating.

081–3.5.6.1 PRAIRIE AIR PROPELLER CLEANING. Prairie air propeller cleaning will be accomplished using only approved materials as described in Section 4.

081–3.5.6.1.1 After cleaning and polishing propeller blade surfaces, provide normal prairie air to propeller blades. Fin stabilizer cutout valves should be closed. Using an approved waterjet system, begin cleaning at the uppermost emitter holes and work downward using the lowest water jet pressure possible to clear emitter holes. In no instance shall water jet pressure be allowed to rise over 10,000 lb/in^{2}g. Individual plugged holes dispersed over the blade can be tolerated; however two or more plugged holes which are adjacent to each other degrade systems' performance.

081–3.5.6.2 PRAIRIE AIR FIN STABILIZER CLEANING. Prairie air fin stabilizer cleaning will be accomplished using only approved materials as described in Section 4.

081–3.5.6.2.1 After cleaning the fin stabilizer surfaces with brush A–1, A–2, or C, provide normal prairie air to the fin stabilizers. Propeller cutout valves should be closed. Using an approved water jet system, begin cleaning at the uppermost emitter holes and work downward using the lowest water jet pressure possible to clean emitter holes.

081–3.5.7 SEA CHEST CLEANING. Sea chest cleaning will be accomplished using only approved materials as described in Section 4.

CAUTION

When using high–pressure water jets to clean sea chests and gratings, do not allow jet stream to contact painted hull surfaces adjacent to sea chests.

081–3.5.7.1 All marine fouling will be removed from sea chests using hand–held scrapers and approved water jet systems.

081–3.5.8 SUBMARINE SPECIAL HULL TREATMENT (SHT) CLEANING. Submarine hulls treated with SHT systems shall not be cleaned without NAVSEA approval. These ships should still be regularly scheduled for interim cleaning and precleaning inspections. Precleaning inspections should be conducted over the entire hull to assess and document the paint system's performance. If, during a hull inspection or interim cleaning, fouling of FR–50 or greater is observed on a hull treated with SHT, photographic documentation by Navy or contractor divers should be obtained and forwarded immediately to NAVSEA Code 00C. NAVSEA will provide cleaning advice for ships treated with SHT on a case basis. All requests should be submitted by fleet activities in the form of Naval messages utilizing the subject line**: Waterborne Hull Cleaning.** Message should include date of inspection, inspection activity, hull paint date and type, date of next scheduled drydocking, and inspection results. In no case should SHT systems be cleaned without specific written approval by NAVSEA.

081–3.5.9 WOOD AND FIBERGLASS HULL CLEANING. Hull cleaning on wood and fiberglass hulls is restricted to hand–held rotary brush units operating with brush A–1 or A–2 only. Hard calcareous fouling must be removed using hand–held scrapers. Propeller cleaning on these ships shall be done in accordance with paragraph 081–3.5.2.

081–3.5.10 FIBERGLASS (GRP) COVERED PROPULSION SHAFTS. Cleaning of fiberglass covered shafts is restricted to hand-held rotary brush units. Hand-held brush type A–2 (polypropylene) should be used to remove biofouling up to FR–50; brush type C (flat wire) may be used to remove any residual fouling or fouling of a higher FR. Extreme caution should be utilized when using the brush type C to prevent damaging the fiberglass (GRP) covering.

NT CLEA FA EB Bow–Mounted Sonar Dome Rubber Window.

F T CNEA LA FB Keel–Mounted Rubber Sonar Dome.

NT CLEA FA FB No–Foul Rubber–Coated Bow.

SECTION 4.
HULL CLEANING EQUIPMENT

081–4.1 AVAILABLE CLEANING METHODS

081–4.1.1 Several types of techniques and tools are available for waterborne cleaning. Authorized contractor personnel have single-brush and large multi-brush equipment which provides efficient results for complete underwater hull cleaning. Navy personnel have access to a variety of cleaning equipment provided the equipment conforms to NAVSEAINST 10560.2, **Diving Equipment Authorized for Navy Use**.

081–4.2 CLEANING EQUIPMENT

081–4.2.1 GENERAL. Five categories of cleaning equipment are in use: hand-held rotary brush units, self–propelled multi–brush cleaning vehicles, water jets, hydrolances and hand-held scrapers. Due to the special configuration of Navy ships and critical areas such as the impressed current cathodic protection system, sonar domes, special appendages and special paint formulas, all underwater hull cleaning equipment shall be diver operated and controlled. The diver shall have voice communications with the surface, and shall have the means, on the equipment, to stop, start, and maneuver hull cleaning equipment.

081–4.2.2 POWERED BRUSHES. Powered brushes are available as single or dual, hand–held rotary brush units or as large self–propelled, multi–brush cleaning vehicles which are driven along the ship hull. The hand–held brushes are powered either hydraulically or pneumatically and utilize one of the brush or disk types defined in paragraph 081–4.2.4. The large, self–propelled, multi–brush vehicles are powered either hydraulically or electrically and may have one or several large brushes as described in Table 081–3–1, thus permitting a wide swath to be cleaned on each pass along the hull. These machines rely on the rotating motion of the brushes or on an impeller to provide the suction force which holds the machine against the hull. The machine is controlled by a diver–operator who guides the vehicle along the hull, steering it around obstructions and along the desired cleaning path. Some typical hand-held rotary brush units are shown in Figure 081–4–1. A large, self–propelled, multi–brush vehicle is shown in Figure 081–4–2.

CAUTION

The use of **barnacle busters** or similar devices is prohibited.

CAUTION

Self–propelled, multi–brush cleaning vehicles are forbidden on sonar domes or on rubber-coated surfaces. It is not permissible to drive such machines across these surfaces.

081–4.2.3 SELF–PROPELLED, MULTI–BRUSH CLEANING VEHICLES. All brushes shall be in good condition and conform to the characteristics listed in Table 081–3–1. All rotating brushes shall be turned off or retracted from the hull during idle periods when the machine is resting on the hull as well as when the machine is being turned on the hull at the end of each swath. Metal type traction grippers are prohibited on any machines as is any device on the wheels which will damage the hull paint.

CAUTION

Brush C is forbidden on rubber or glass reinforced plastic (GRP) sonar domes or rubber–coated surfaces.

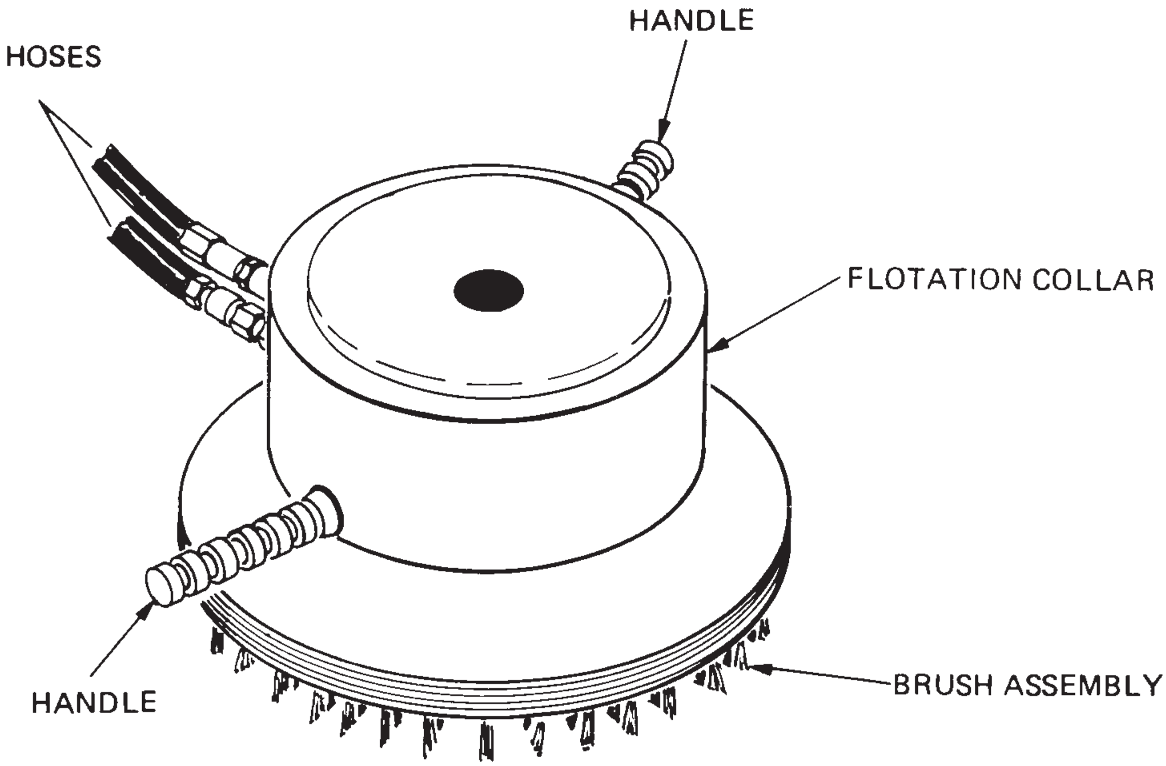


Figure 081–4–1. Hand–Held Rotary Brush Unit with Brush A

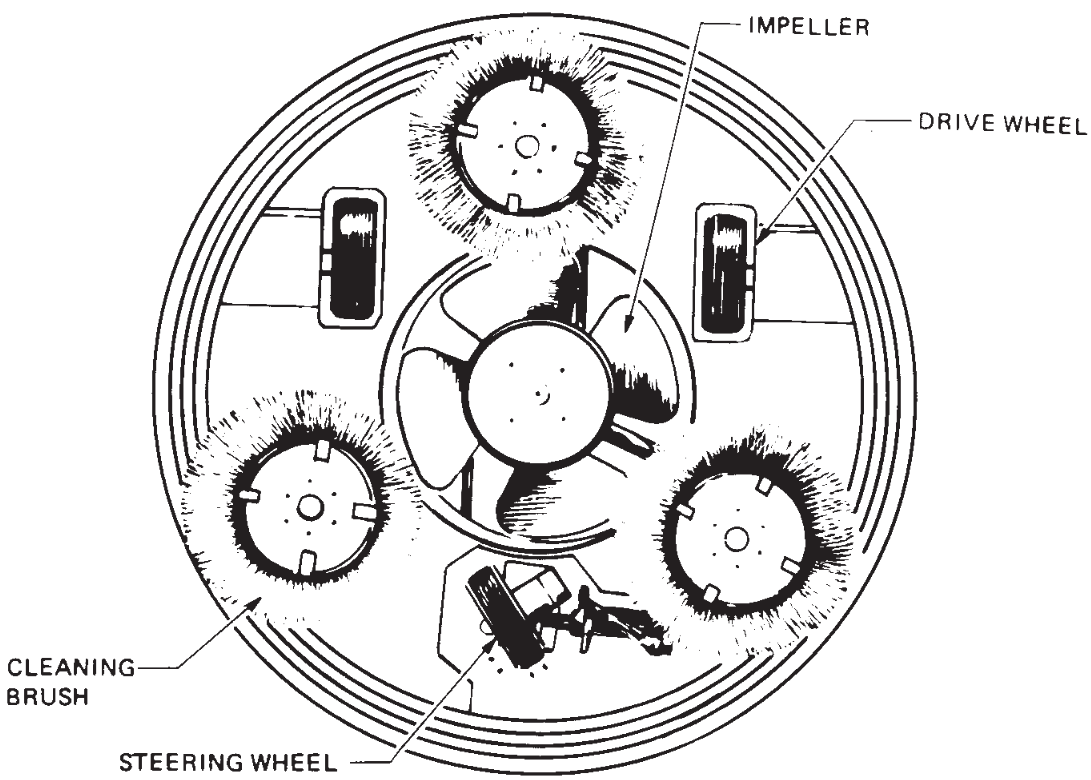


Figure 081–4–2. Typical Multi–Brush Cleaning Machine

CAUTION

The use of **barnacle busters** or similar devices is prohibited.

081–4.2.4 HAND–HELD ROTARY BRUSH UNITS. Hand–held rotary brush units may be employed to clean those areas inaccessible to self–propelled machines or those areas in which self–propelled machines are prohibited. Rotary hydraulic diver tools which operate at 600 to 1,300 revolutions per minute (r/min) should be used. The brushes/disks used on these units shall be in good condition, conform to the characteristics listed in Table 081–3–1, and be used in accordance with the following:

a. Brush A–1, having stiff nylon bristles (Figure 081–4–3), may be used to clean all areas of propellers, painted and unpainted surfaces, rubber sonar domes and rubber–coated surfaces, and submarine GRP sonar domes. Brush A–2 (Figure 081–4–4), having stiff polypropylene bristles, may be used to clean all areas of propellers, painted and unpainted surfaces, GRP coated shafts, and wooden or fiberglass hulls.

b. Brush C, having flat wire steel bristles (Figure 081–4–5), may be used to clean all but the outer 6–inch periphery of all propellers, masker emitter belts, and on painted areas not accessible to self–propelled, multi–brush cleaning vehicles. On propeller surfaces, brush C should be used only as a last resort (and then only by a highly trained diver) to remove severe fouling. Because of its configuration, brush C can cause scratches and gouges on propeller surfaces if used by an inexperienced diver.

CAUTION

Brush D and abrasive disks D3 and D5 shall be used on unpainted surfaces only.

c. Brush D, having nylon bristles impregnated with silicon carbide (Figure 081–4–6), may be used to clean all areas of all propellers.

d. Disk D3, a 3–density abrasive marine cleaning disk, may be used to clean all areas of all propellers, unpainted copper–nickel masker emitter belts, rubber sonar domes, and rubber-coated surfaces.

e. Disk D5, a 5–density abrasive marine cleaning disk, may be used to clean all areas of all propellers, and unpainted, copper-nickel masker emitter belts.

CAUTION

Water jet systems are forbidden on sonar domes and rubber-coated surfaces. At no time should water jets being used on propeller surfaces be allowed to operate at pressures above 10,000 pounds per square inch gage (lb/in^{2}g).

081–4.2.5 WATER JET USE. Authorized high–pressure water jets are to be used predominantly on unpainted surfaces such as masker belts and propellers. Such systems are prohibited from use on rubber or rubber–coated sonar domes and surfaces, or GRP sonar domes. At no time should water jets being used on propellers be allowed to operate at pressures above 10,000 lb/in^{2}g. Use of water jets on painted surfaces is restricted to sea chests and painted masker air emitter systems when it is necessary to clean masker emitter holes.

081–4.2.6 WATER JETS. Water jet systems which have been authorized for Navy use for divers (NAVSEAINST 10560.2) may be used to remove fouling as noted in paragraph 081–4.2.5. Two types of systems are available: cavitating systems and noncavitating systems. Cavitating systems utilize a nozzle especially designed to induce cavitation at the surface being cleaned. The advantage of this type system is that a lower water pressure can be used to remove fouling, since much of the cleaning energy needed is provided by the cavitation effect itself. Noncavitating systems rely solely on the energy contained in the water jet itself, and thus require a higher operating pressure to achieve the same cleaning effectiveness as cavitating systems. Some typical

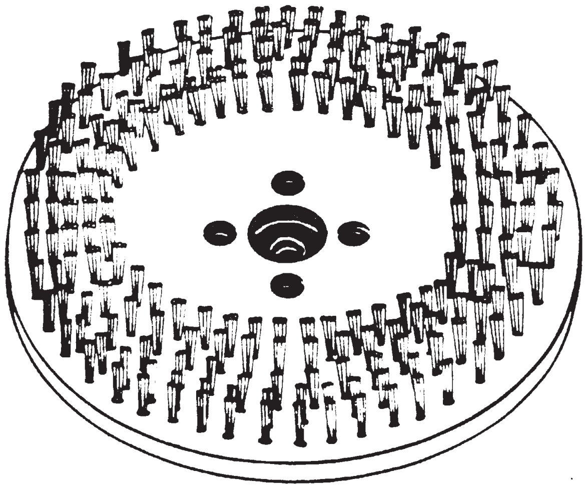


Figure 081–4–3. Brush A–1 – Stiff Round Nylon Bristles

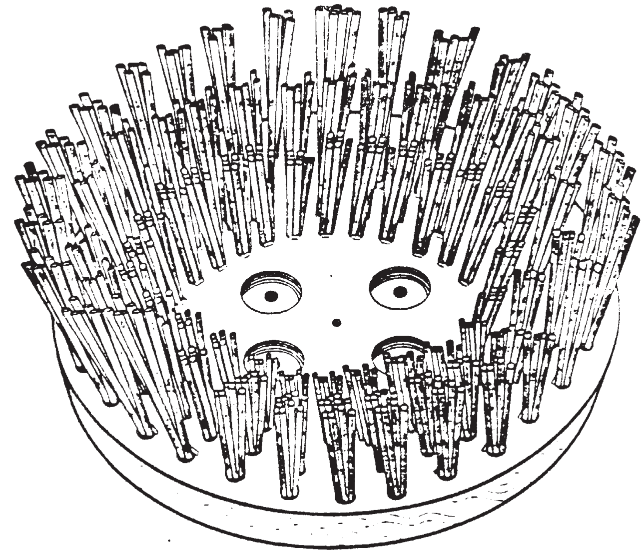


Figure 081–4–4. Brush A–2 – Stiff Round Polypropylene Angled Bristles

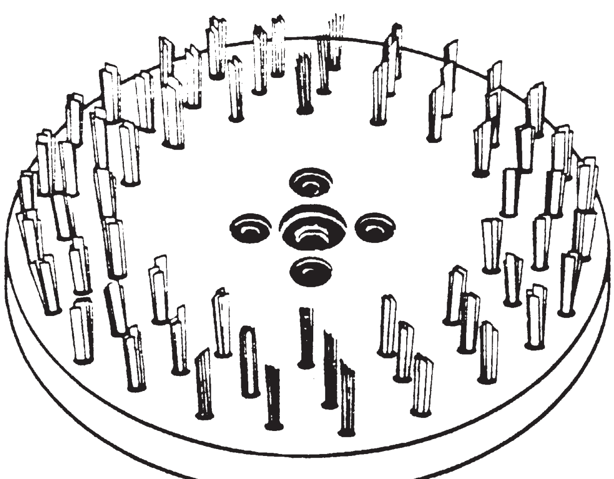


Figure 081–4–5. Brush C – Flat Wire Steel Bristles

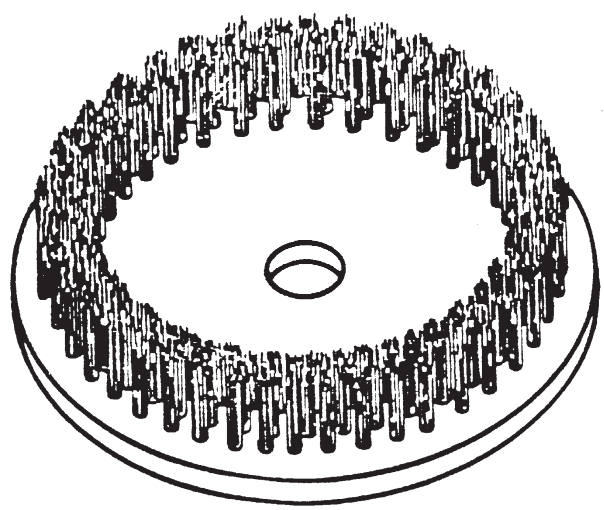


Figure 081–4–6. Brush D – Silicon Carbide Imbedded in Nylon Bristles

water jet systems are shown in Figure 081–4–7. Unlike conventional water jets used for surface operations, diver operated water jets contain a zero thrust nozzle which discharges a second stream of water in the opposite direction of the cleaning stream to negate the thrust and permit the diver to work more easily and efficiently.

081–4.2.7 HYDROLANCE USE. Authorized high pressure flexible lances are to be used predominantly for internal cleaning of masker air emitter belts and hub air (rope guard and fairwater). At no time shall the hydrolance be allowed to operate at pressures exceeding the limits specified in the applicable cleaning procedures.

081–4.2.8 HYDROLANCES. Hydrolance systems which are authorized for Navy use for divers (NAVSEAINST 10560.2) may be used to remove fouling and calcium accumulation as noted in paragraph 081–4.2.7.

081–4.2.9 HAND–HELD SCRAPERS. Various types of wooden, plastic, or brass (which is softer than propeller bronze) scrapers are used to remove fouling from propeller blades and hub areas (see paragraph 081–3.5.2). In those instances where it is necessary to remove calcareous growth from sonar domes, it is permissible to use wooden scrapers. However, extreme care shall be exercised to prevent damage (see paragraph 081–3.5.3.2). Some typical scrapers are shown in Figure 081–4–8.

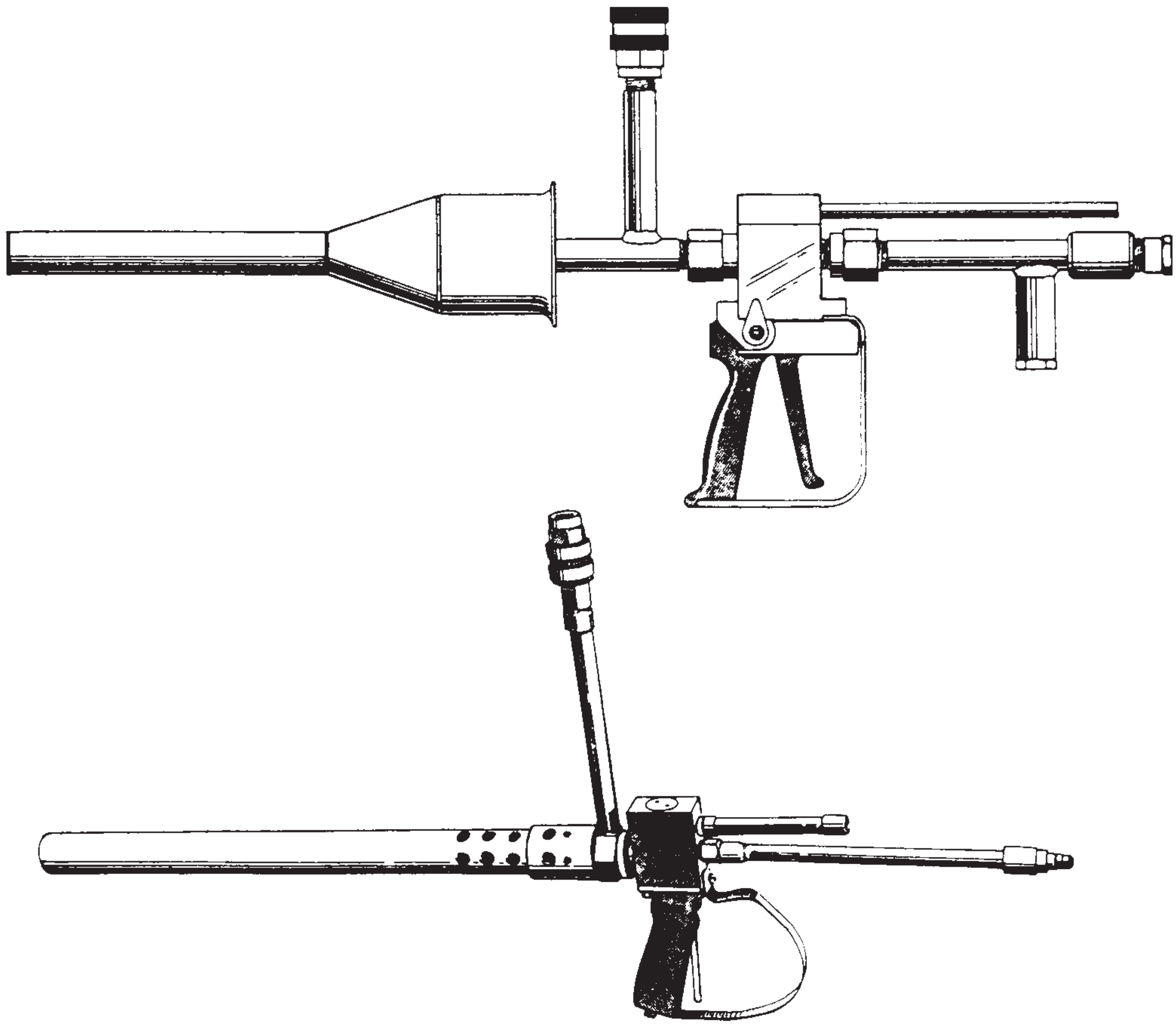


Figure 081–4–7. Typical Water Jet Systems

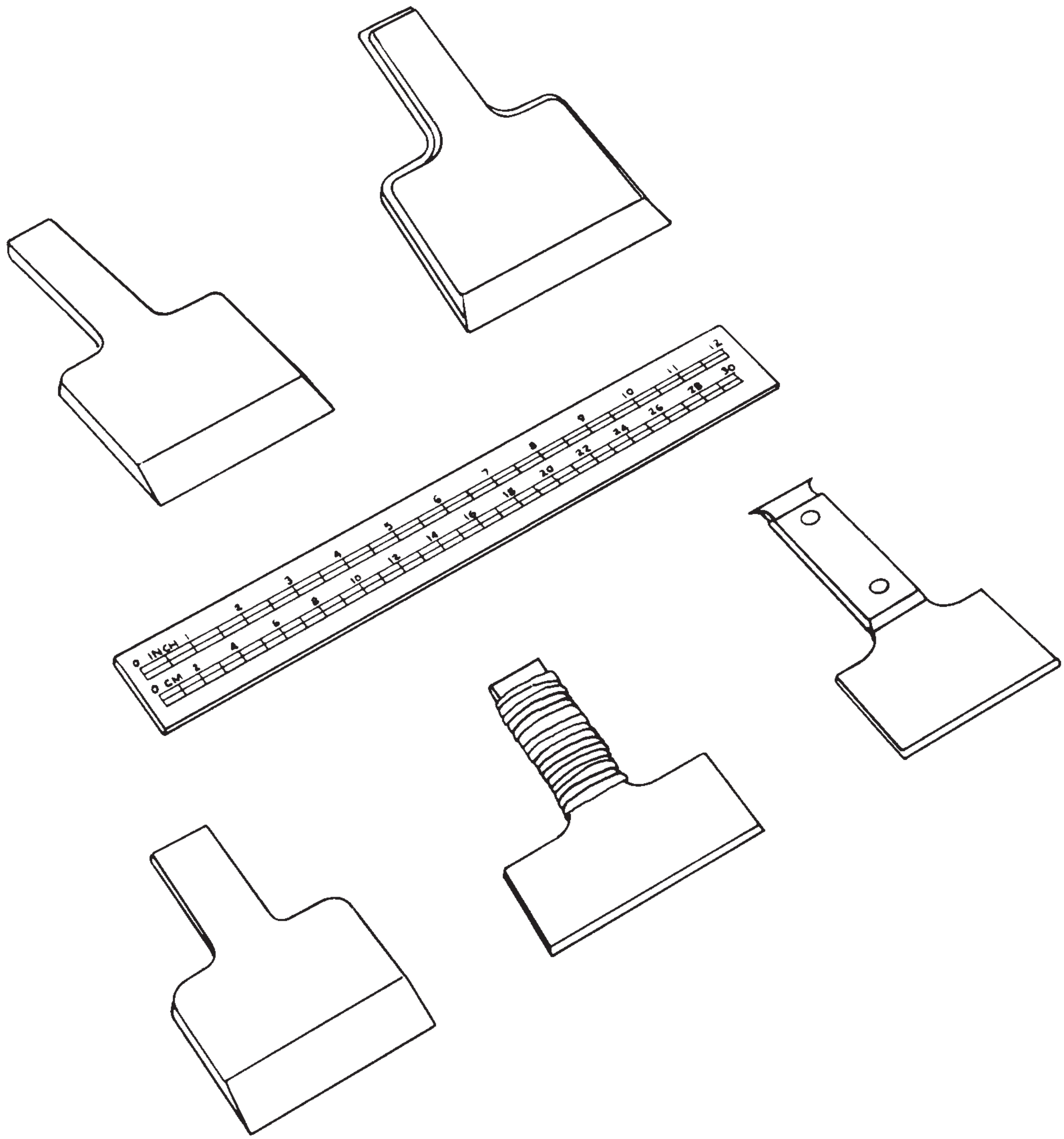


Figure 081–4–8. Typical Scrapers

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